Cameras

- First photograph due to Niepce
- First on record shown in the book - 1822
- Basic abstraction is the pinhole camera
  - lenses required to ensure image is not too dark
  - various other abstractions can be applied

Image Formation

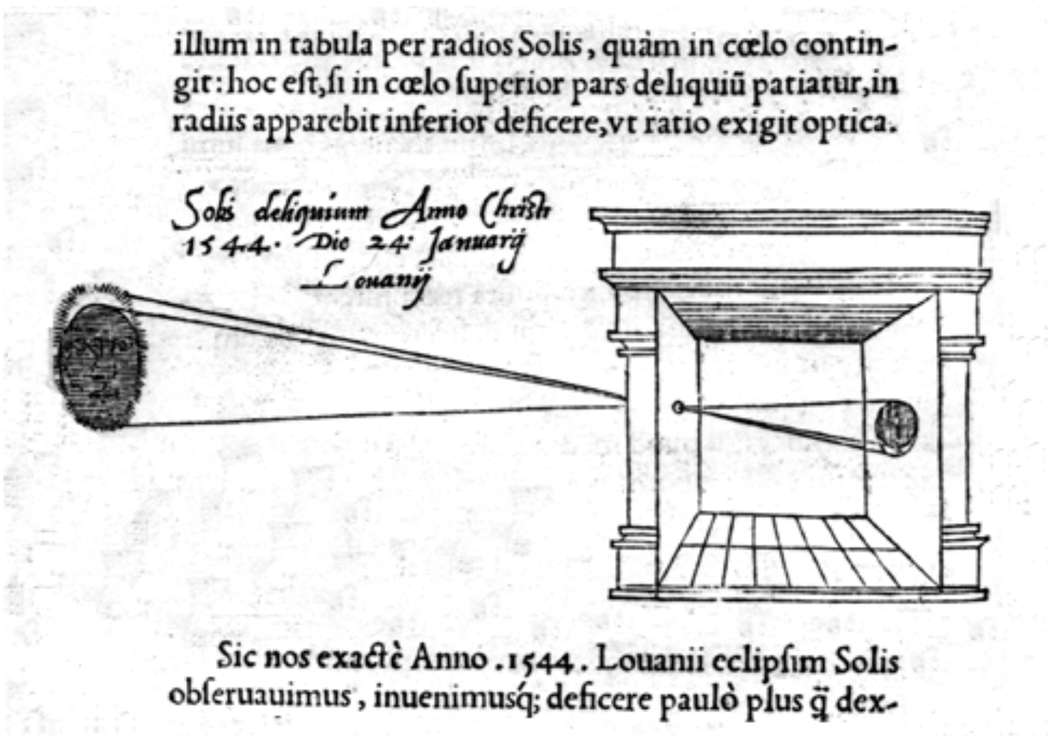
- Optics (geometry)
- Photometry (physics)

La “camera ottica”

- Conosciuta sin dall’antichita’ (Aristotele ne accenna l’esistenza nel 330 a.C.), e’ l’antenato della moderna macchina fotografica

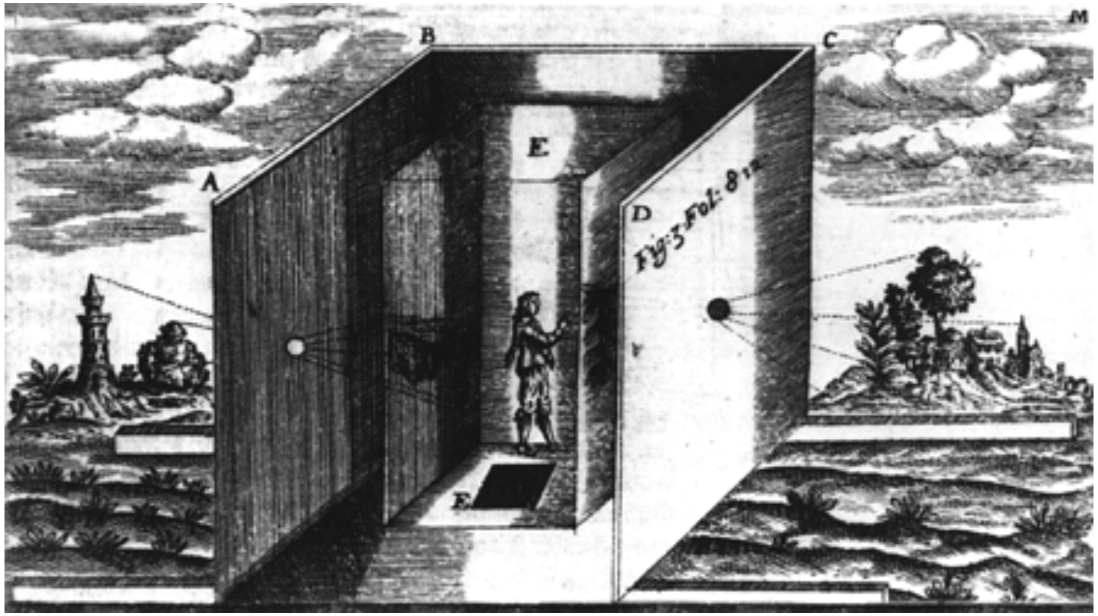
Camere oscure negli USA

Camera Obscura, Reinerus Gemma-Frisius, 1544


illum in tabula per radios Solis, quàm in cœlo contin-
git: hoc eſt, ſi in cœlo ſuperior pars deliquiũ patiatur, in
radiis apparebit inferior deficere, vt ratio exigit optica.

Sic nos exactè Anno .1544. Louanii eclipſim Solis
obſeruauimus, inuenimusq; deficere paulò plus q̃ dex-

Camera Obscura, Athanasius Kircher, 1646



- Camera oscura a
- San Francisco

CAMERA OBSCURA
SAN FRANCISCO
1096 POINT LOBOS, SAN FRANCISCO, CA 94121, Tel: (415) 750-0415

Seal Rock area magnified 360°

HISTORY:
The word Camera Obscura is Latin and means translated the 'dark room'. Today it is not quite known, when and by whom exactly the Camera Obscura was invented. In the 11th. century the Arabian scholar Alhazen theorized that light waves travel in straight lines and he tried to proof it with a pinhole. What happened between then and the end of the 15th. century is obscure. The oldest forms of the Camera Obscura surviving, are sketches by Leonardo da Vinci and others, probably from around the late 15th. century. He was most likely not the only one, because around 1490 John Baptista della Porta revealed the phenomena in a book called 'Natural Magic'. While it was to the amusement of those scholars, other people condemned it as an invention of the devil.
In the following centuries, the Camera Obscura became a wonderful tool for artists and astronomers. Artists, such as Vermeer, used the Camera Obscura as portable instruments for their paintings and portrait drawings.

10" DIAMETER FRONT FACED MIRROR
8" CONVEX LENS
8" CONCAVE LENS
25' x 25' Building
PARABOLIC SCREEN
Exit
Entrance
Camera Obscura "Giant Camera"

Rotating on top of the camera in the copper pyramid is a 10" surface coated mirror of high brilliance which reflects an image through the condensing lenses mounted horizontally directly beneath the mirror. The condensing lenses are simple plano-convex lenses mounted in opposition to each other. They focus the un-focused image from the mirror at a specific distance, in this case 12'. The lens size is 8" and the lens aperture is fixed at F8.

EXPERIENCE THE CAMERA OBSCURA EFFECT

History
The Camera Obscura is the last remaining structure of the World Famous Playland at the Beach. Built by Floyd Jennings in 1946. It was built with the permission of George K. Whitney Sr., then owner of the Cliff House, Sutro Baths and Playland. Mr. Whitney later suggested, to making it look like a Camera, hence the name Giant Camera. This rare attraction is in keeping with Sutro's plan for recreational activities at Point Lobos. This structure provides scenic panoramic views, so spectacular with vivid colors. Making it a fun and learning experience. **Walk** through this optical instrument, which produces 360 degrees of spectacular **Live Images** of the **Seal Rock Area**. Magnified Seven Times on a Six foot Parabolic Table. **Now** you can expeience this **Special Effect**. You will be truly amazed, the **Images** standing up and coming at you. After this you will want to learn everything you can about the **CAMERA OBSCURA**. You will be telling your friends. Don't miss it.

This rare optical device, shows you SEAL ROCK AREA in a new way.
It produces a spectacular **LIVE IMAGE** magnified seven times.

The Giant Camera is now a National Landmark, and is on the National Register of Historic Places. Now, you can share this Treasure box with your family and friends. You have been exposed to the Camera Obscura Effect. Tell everyone to visit today.

The Camera is Always open from 11:00 am. 'til sunset on beautiful days, and probably a little bit shorter on other days. To make sure, give us a call at (415) 750-0415.

General Admission - TWO DOLLARS EACH

Seniors 65 and up - ONE DOLLAR EACH

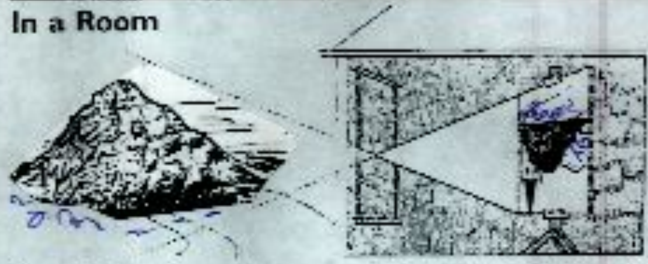
CHILDREN 12 and under- ONE DOLLAR EACH

SUNSETS~Observe the sun with safety and amusement. See sunspots, solar flares and such phenomena as the **GREEN FLASH**. The sunsets are spectacular and should be seen by everyone.

You can forward more information to your family and friends
http://www.giantcamera.com

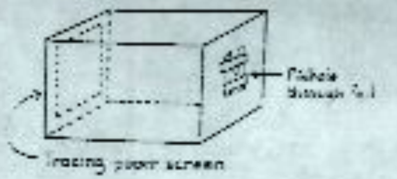
MAKE YOUR OWN CAMERA OBSCURA

In a Room



Shut out all the light from a room by covering the window with a well fitted card or piece of hardboard. Bore a hole through the card or board. An upside down, moving colour image of the scene outside will appear on a piece of paper held opposite the hole. Experiment with different sizes of holes and see the effect on the image.

From a Box



A portable camera obscura can be made out of a cardboard box. First tape up the box to ensure that no light can penetrate, then cut away part of one end of the box and fix a screen of tracing paper across it. At the opposite end cut a 75mm hole in the box, cover this with kitchen foil, tape down the edges and bore a neat round hole through the foil that is no larger than the lead of a pencil. Take the box outside, or to a window, shutting out as much light as possible with a thick blanket. An upside down image of the scene outside will be seen on the screen.

Acknowledgements
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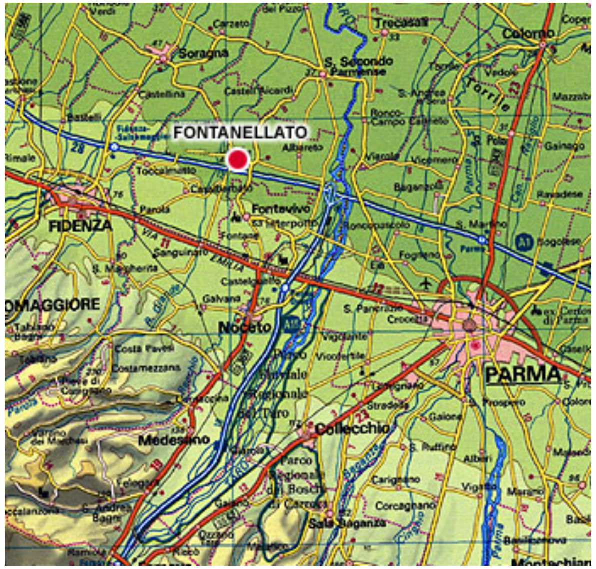
Set: Cameras
Slides by D.A. Forsyth

Camere oscure nel mondo …

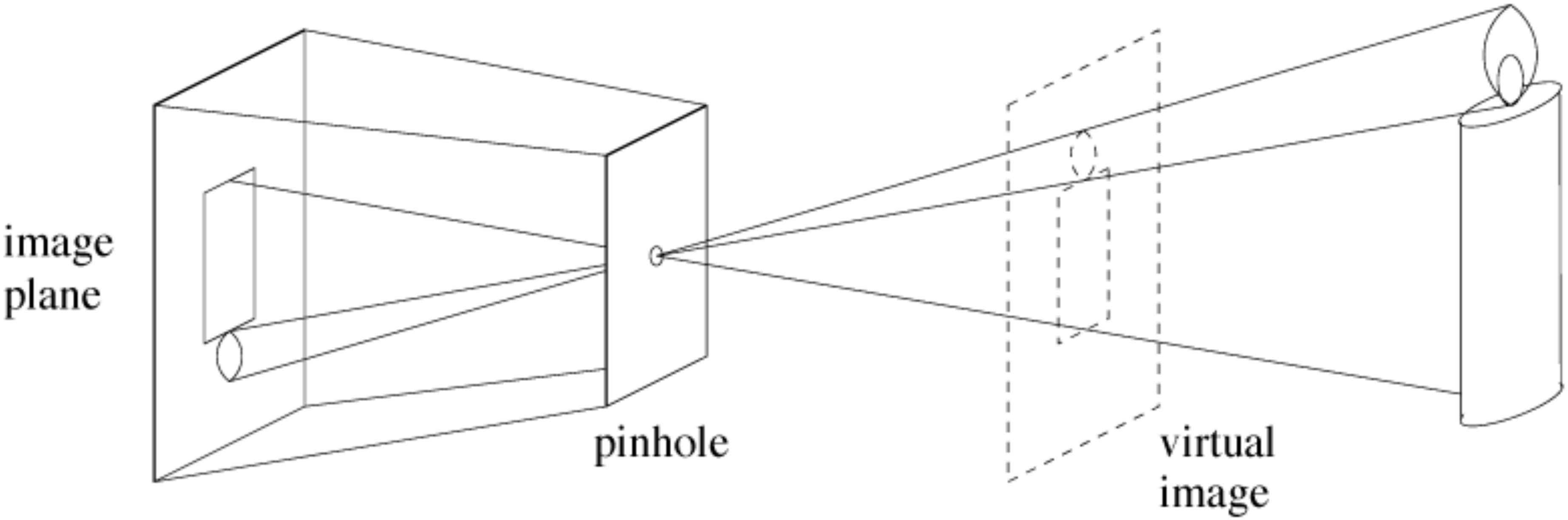
ABERYSTWYTH	WALES	1985	12".5 f20 IN PURPOSE-BUILT TOWER
AIKEN	USA	CURRENT	IN DUPONT PLANETARIUM, SOUTH CAROLINA, PINHOLE TYPE
ALTADENA	USA	CURRENT	PRIVATELY-OWNED. 6" f15
BIEL	SWITZERLAND	CURRENT	AT MUSEUM NEUHAUS
BRADFORD	ENGLAND	-	VARIOUS SMALL CAMERA OBSCURAS
BRIGHTON & HOVE	ENGLAND	1996	TENT CAMERA OBSCURA 4" LENS f26. PORTABLE
BRISTOL	ENGLAND	1829	5" LENS. IN A CONVERTED SNUFF MILL
CADIZ	SPAIN	1994	12" LENS f17. IN WATCH TOWER
CAMBERWELL	ENGLAND	1992	8" LENS f25. PRIVATELY-OWNED
CHESTER	ENGLAND	C1993	5" LENS f14? RESITING OF STOKE OPTICS (Q.V.).
DUDLEY	ENGLAND	CURRENT	AT DUDLEY ZOO & CASTLE
DUMFRIES	SCOTLAND	1836	9" LENS f16. IN CONVERTED WINDMILL
EDINBURGH	SCOTLAND	1947*	COMPLEX LENS. OPENED 1853 (* NEW OPTICS)
EGER	HUNGARY	1700s ONWARDS	IN ASTRONOMICAL TOWER. 6" LENS 9ft FOCAL LENGTH
ENDINGEN	SWITZERLAND	1995	('ONE OF TWO IN SWITZERLAND'!)
FRANKFURT	GERMANY	1995	IN TENT CAMERA OBSCURA, IN MUSEUM
GRAHAMSTOWN	S AFRICA	1882/83	5" LENS (STOPPED DOWN FROM 9")
GREENPORT, NY	USA	1997	SEMI-PORTABLE, PLYWOOD BUILDING. 4ft SCREEN. 2" LENS f1. 78"
GREENWICH	ENGLAND	1994	8" LENS f34. AT OLD GREENWICH OBS.
HAINICHEN	GERMANY	1883	REOPENED 1985
ILFRACOMBE	ENGLAND	1993?	WATERMOUTH CASTLE. IN GNOMELAND
KIRRIEMUIR	SCOTLAND	1929	7" LENS f15. IN CRICKET PAVILON
KNIGHTON	WALES	1994	13" LENS f15. IN ASTRONOMICAL OBSERVATORY
KYOTO	JAPAN	?	AT THE NAKAGAWA PHOTO MUSEUM OR MUSEUM OF KYOTO
LISBON	PORTUGAL	1997	12.25" LENS FL 7.25 METRES. ST GEORGE'S CASTLE. BY SINDEN
LONG MELFORD	ENGLAND	1993>	PINHOLE CAMERA & WITH SMAL LENS. AT KENTWELL HALL.
LLANDUDNO	WALES	?	4" LENS. RECENT.
LOS ANGELES	USA	1953?	10" LENS f12. FIXED-VIEW, SIMPLE LENS
MANCHESTER	ENGLAND	1995	MUSEUM OF SCIENCE & INDUSTRY. INDOOR VIEWS. 'UNEXCITING'.
MIDDLE WALLOP	ENGLAND	1997	8.125" LENS WITH FL OF 16ft. INTERACTIVE SCIENCE CENTRE
MONT ST. MICHEL	FRANCE	?	NOT IN ABBEY. AT LEAST 20 YEARS OLD.
MüLHEIM	GERMANY	1992	5½" LENS f65. IN OLD RAILWAY WATERTOWER.
NAPIER	NZ	1970s	IN AQUARIUM, AUTOMATED. THREE-LENS SYSTEM 8"
NEVADA	USA	ANNUALLY	AT BURNING MAN FESTIVAL. TEMP.
OXFORD	ENGLAND	?	70mm LENS (1 DIOPTRE). CURIOXITY MUSEUM.
OYBIN	GERMANY	1983	8" LENS f14.8. REPLACE 1852 CAMERA OBSCURA.
PARMA	ITALY	?	IN FONTANELLATO CASTLE.
PALMERSTON NORTH	NZ	CURRENT	OLD MENISCUS LENS. RE-CREATED.
PORTLAND	USA	1994	12" TRIPLE STOPPED TO 7.123 AT CHILDREN'S MUSEUM
PORTMEIRION	WALES	1922?	LENS FROM SUBMARIN
PORTSLADE	ENGLAND	1991	12" LENS f18. IN WATEROVER. FROM GATESHEAD(Q.V.).
PRETORIA	SA	CURRENT	AT THE EXPLORATORIUM, UNIVERSITY OF PRETORIA
RADLETT	ENGLAND	CURRENT	NEW SITE FOR DALL'S LUTON CAMERA OBSCURA
RIVERSIDE	USA	1989	CALIFORNIA MUSEUM OF PHOTOGRAPHY
ROCHESTER	USA	CURRENT	GEORGE EASTMAN HOUSE.
SAN FRANCISCO	USA	1989	PRIVATE. ON TELEGRAPH HILL. 6" LENS f30.
SAN FRANCISCO	USA	1948/49	8" LENS f19. IN CAMERA-SHAPED BUILDING.
SANTA MONICA	USA	1955	BUILT 1899 ON DIFFERENT SITE.
SOUTHAMPTON	USA	1955	MR WAKEFIELD, IN ROOF OF HOUSE. 6½ f21.
STOKE-ON-TRENT	ENGLAND	1997	TEMPORARY. STAFF. UNIVERSITY. 4" LENS f15. Ms J.GRIGGS.
TODMORDEN	ENGLAND	?	5" LENS f22. AT AMATEUR ASTRO. CENTRE. BEING RENOVATED.
TODMORDEN	ENGLAND	1995	6" LENS f11. IN ROOF OF WORKSHOP.
WORTHING	ENGLAND	1996	PORTABLE, PRIVATE.
MONT ST. MICHEL	FRANCHE		
GOTHA CASTLE	GERMANY		
EGGER	HUNGARY		
PARMA	ITALY		
TOOWOMBA	AUSTRALIA		
NAPIER	ENGLAND		

… e in Italia (Rocca di Sanvitale, Fontanellato, Parma)

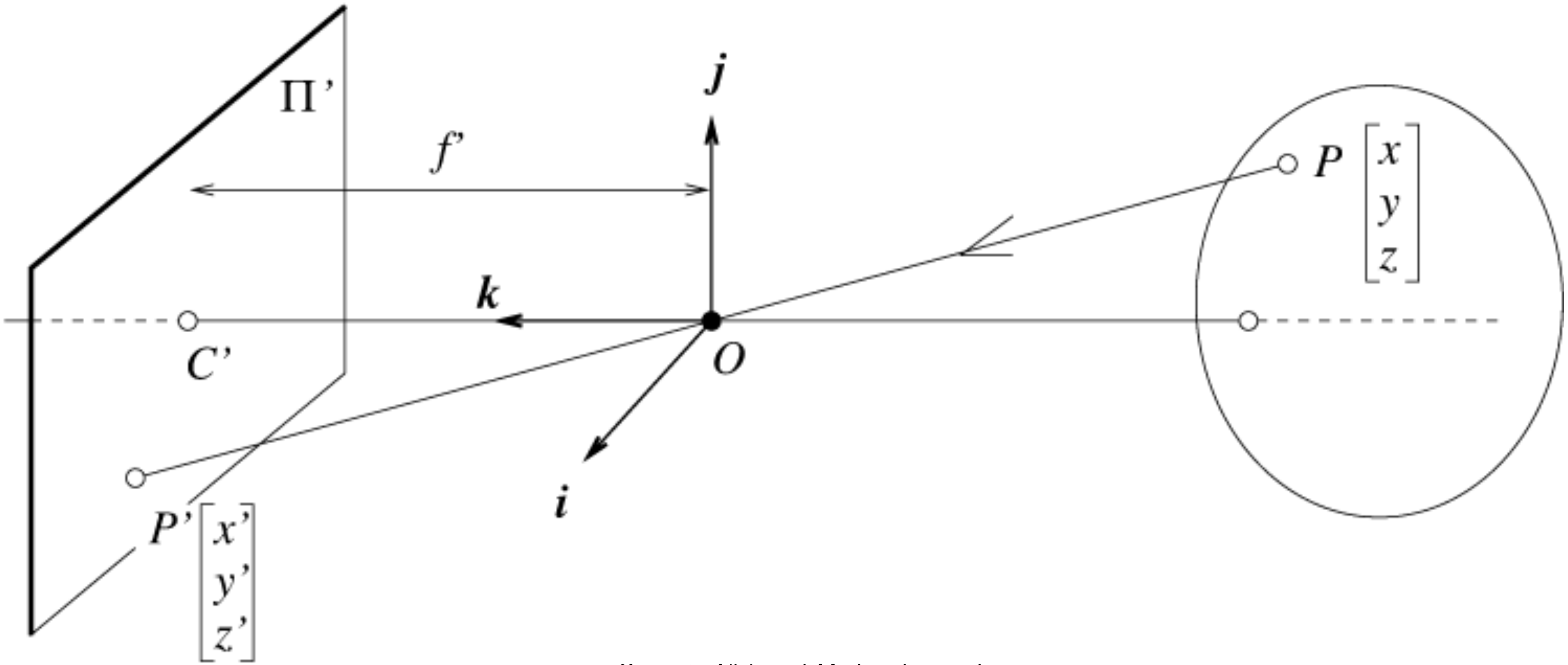


Pinhole cameras

- Abstract camera model - box with a small hole in it
- Pinhole cameras work in practice



The equation of projection



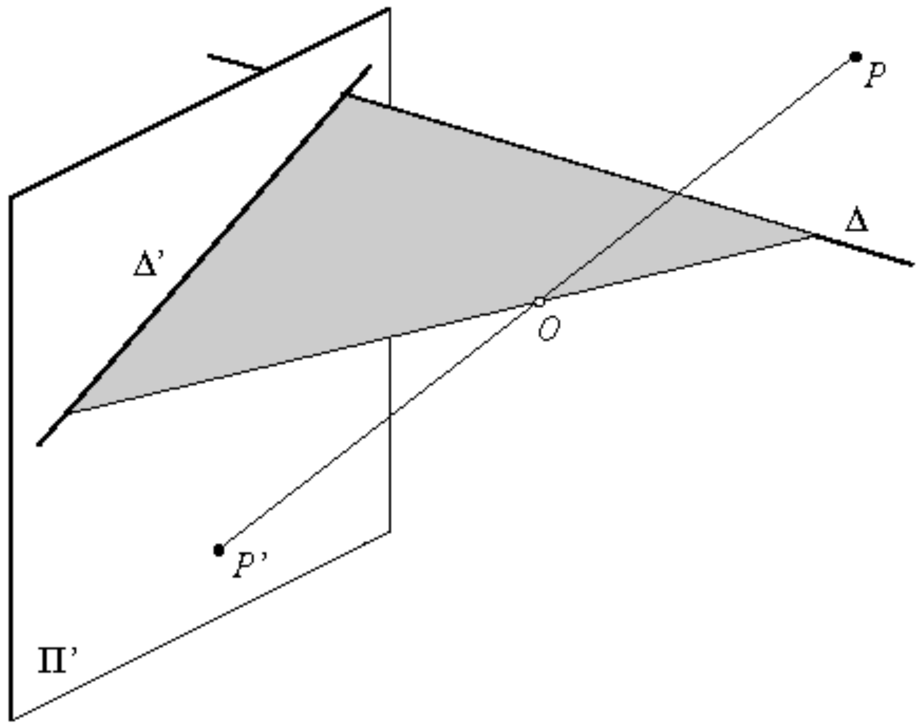
The equation of projection

- Cartesian coordinates:
  - We have, by similar triangles, that (x, y, z) -> (f x/z, f y/z, -f)
  - Ignore the third coordinate, and get

$$(x, y, z) \to (f\frac{x}{z}, f\frac{y}{z})$$

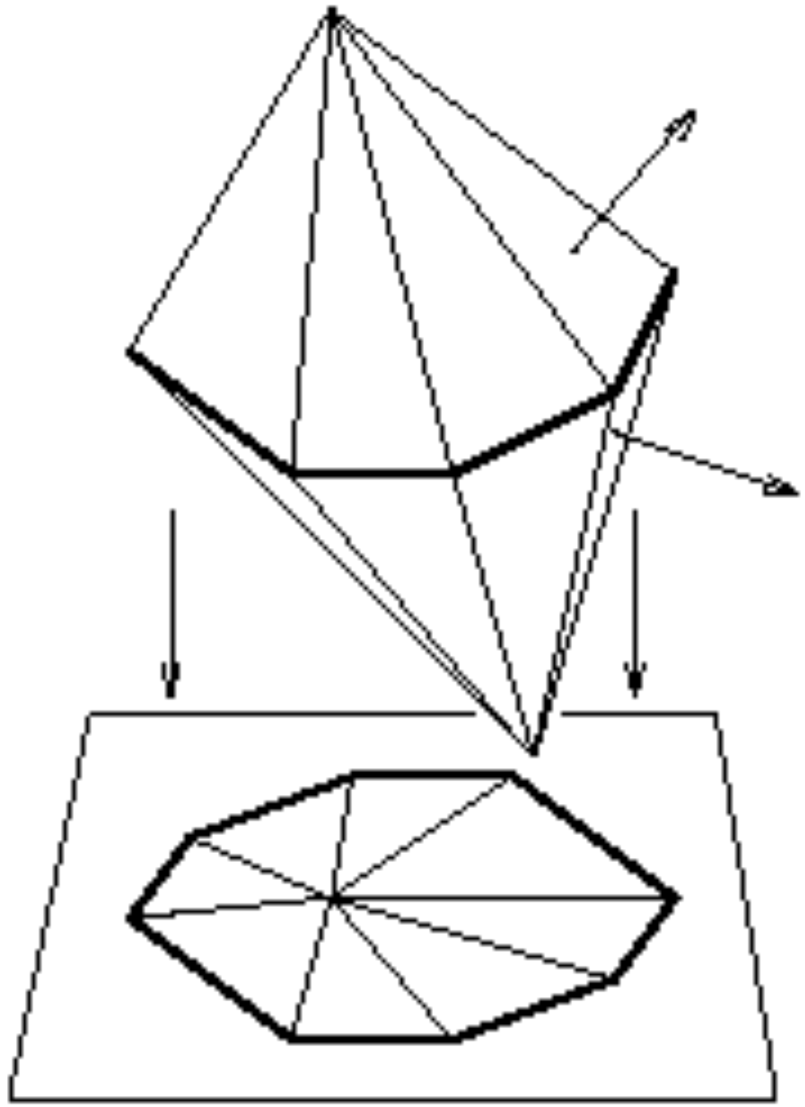
Geometric properties of projection

- Points go to points
- Lines go to lines
- Planes go to whole image
- Polygons go to polygons
- Degenerate cases
  – line through focal point to point
  – plane through focal point to line

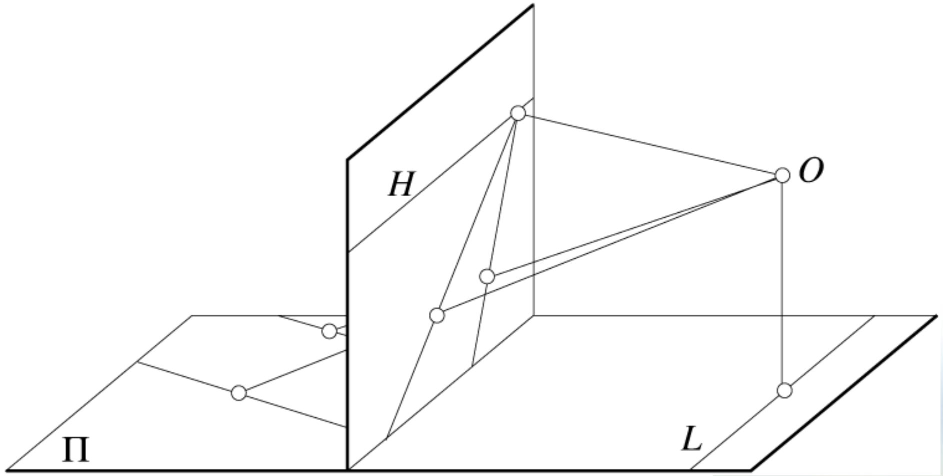


Polyhedra project to polygons

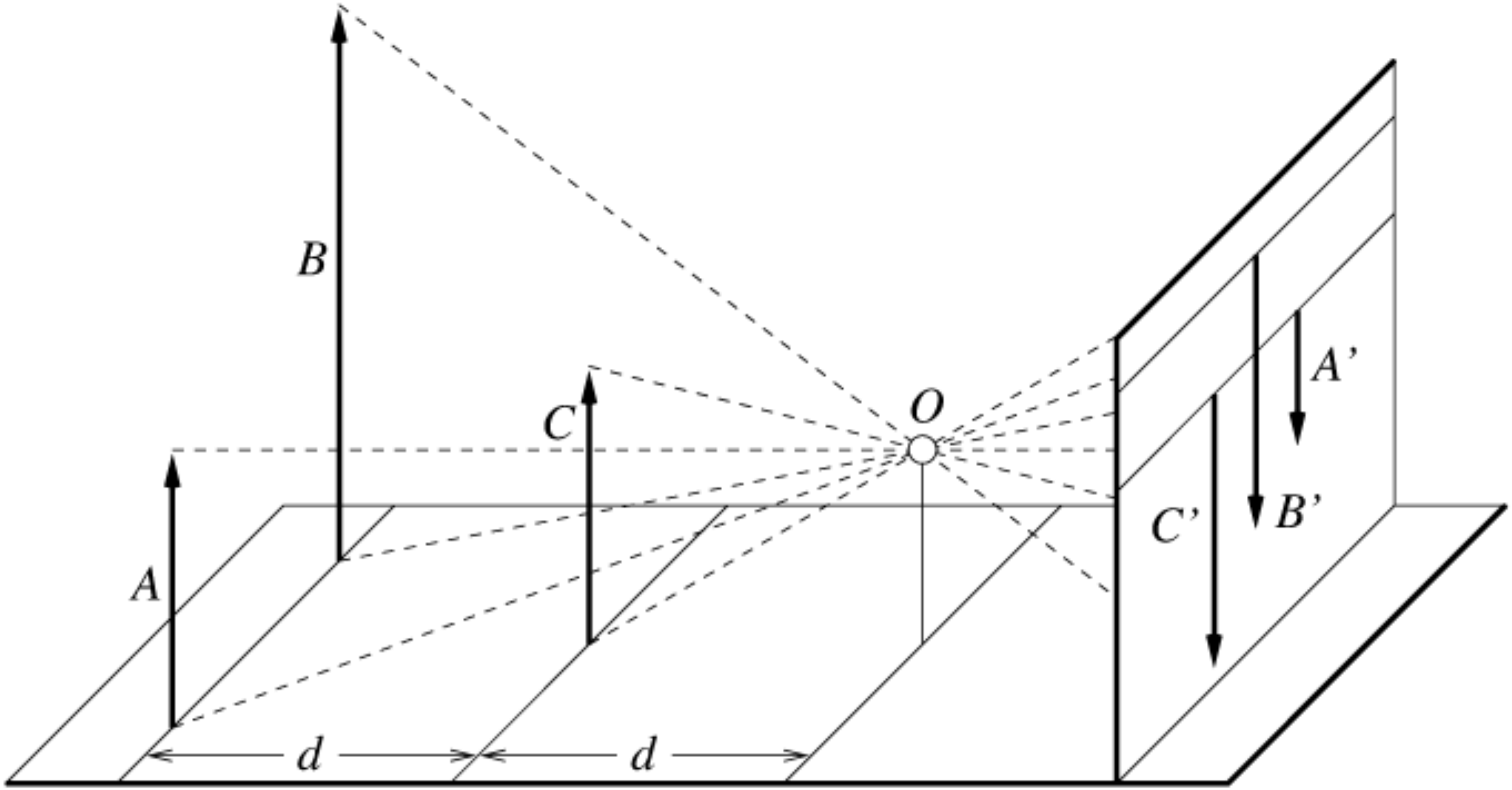
- (because lines project to lines)



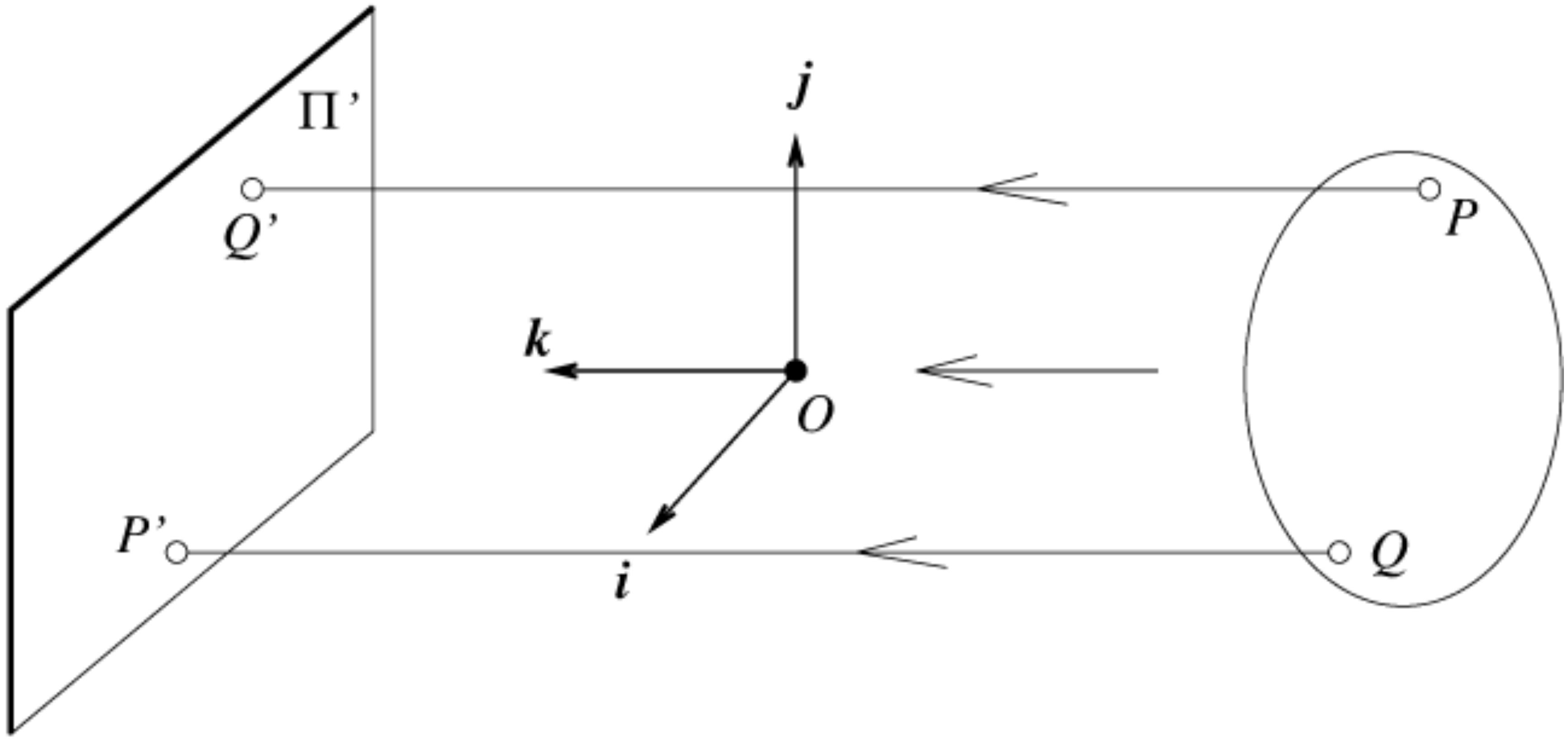
Parallel lines converge



Distant objects are smaller



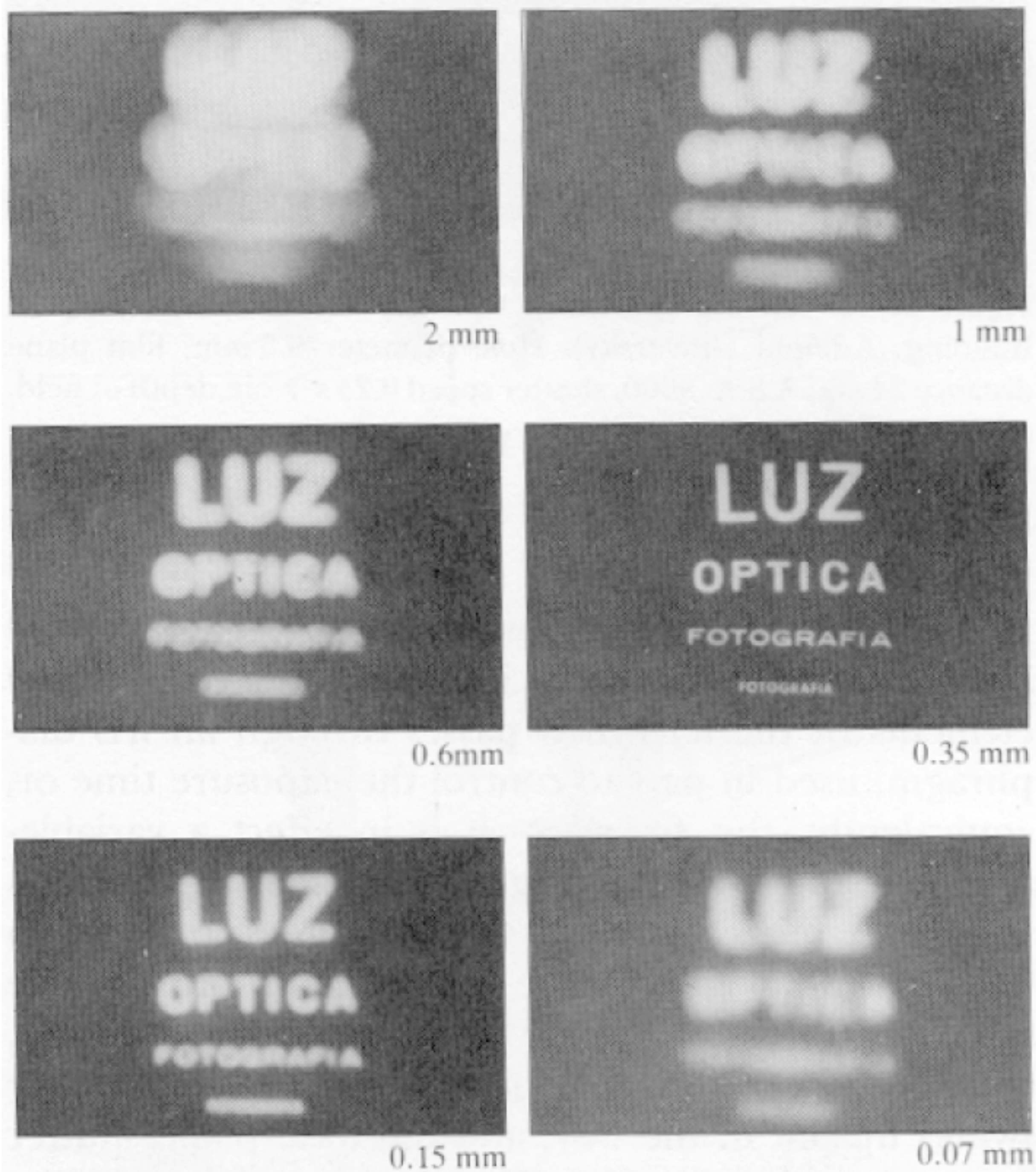
Orthographic projection



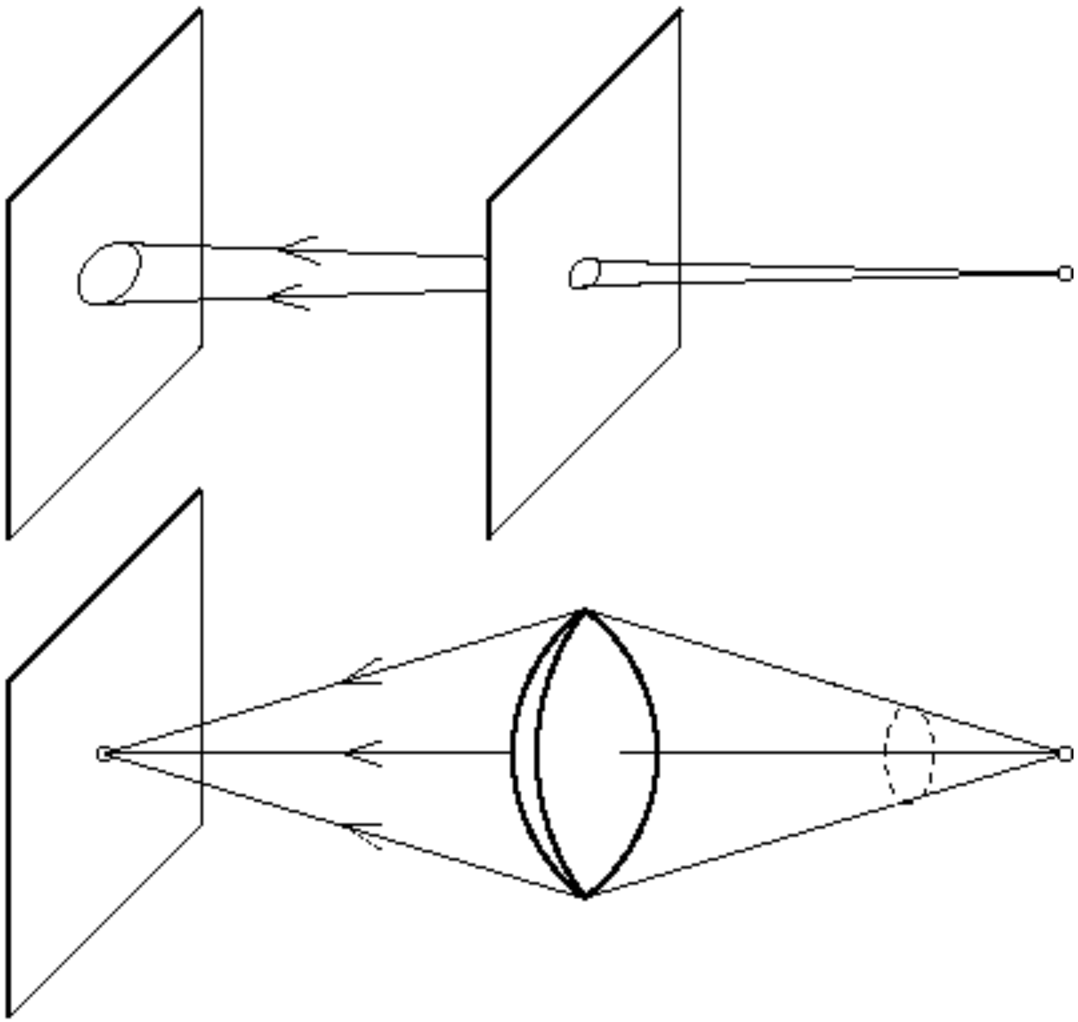
Pinhole too big -
many directions are averaged, blurring the image

Pinhole too small-
diffraction effects blur the image

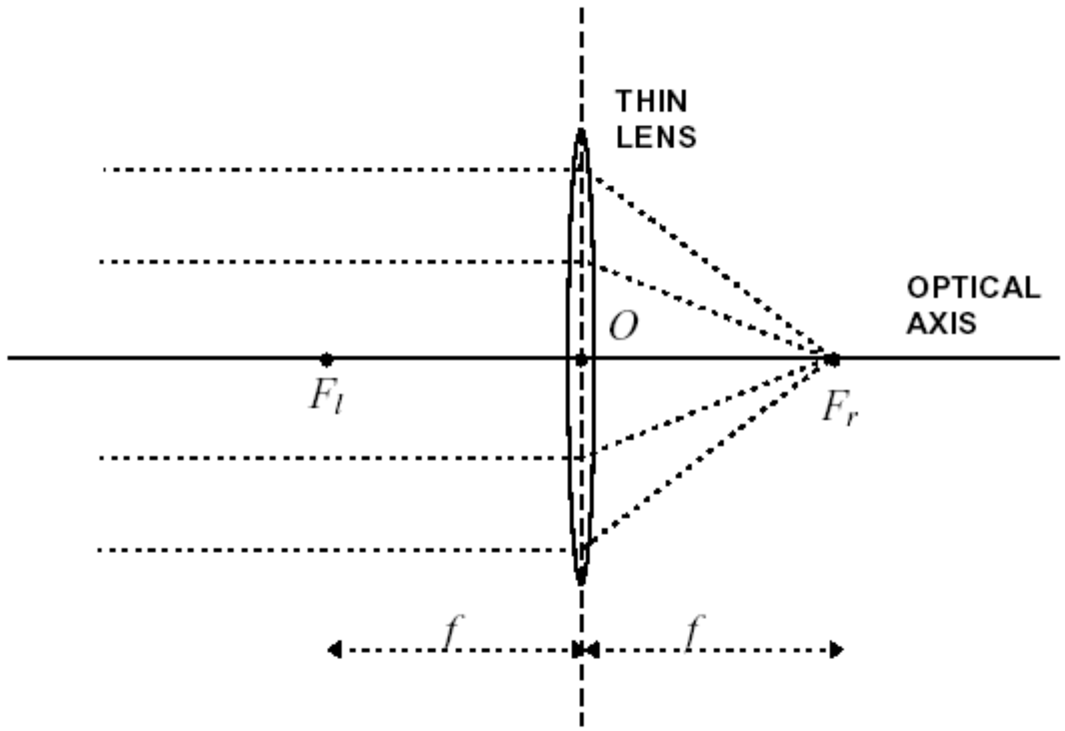
Generally, pinhole cameras are *dark*, because a very small set of rays from a particular point hits the screen.

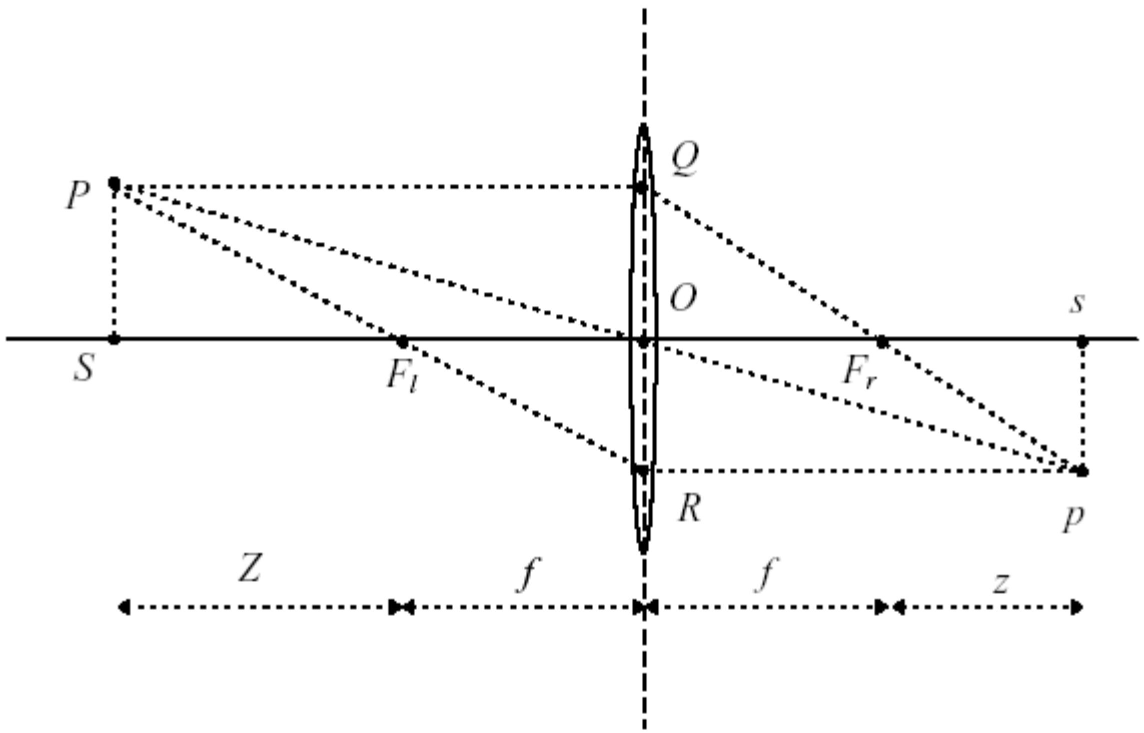


The reason for lenses



Thin lenses





$$Zz = f^2$$

Basic radiometry

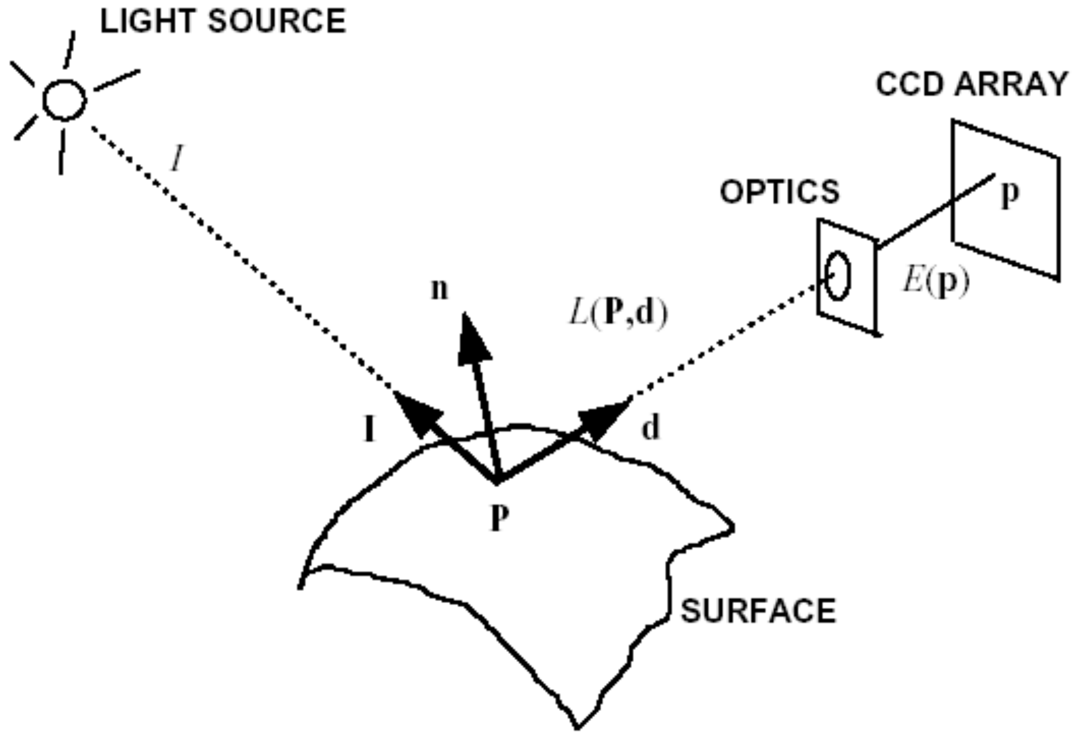


Image Irradiance E: the power of the light, per unit area and at each point $\mathbf{p}$ of the image plane.

Scene Irradiance L: the power of light, per unit area, ideally emitted by each point $\mathbf{P}$ of a surface in 3-D space in a given direction $\mathbf{d}$.

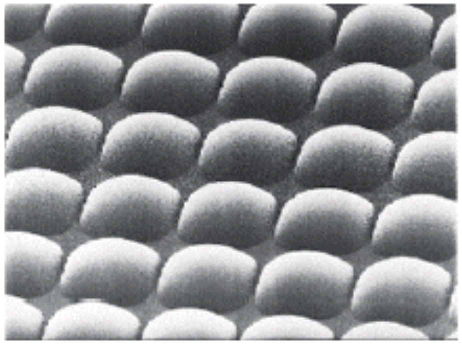
The Lambertian model for surface reflectance

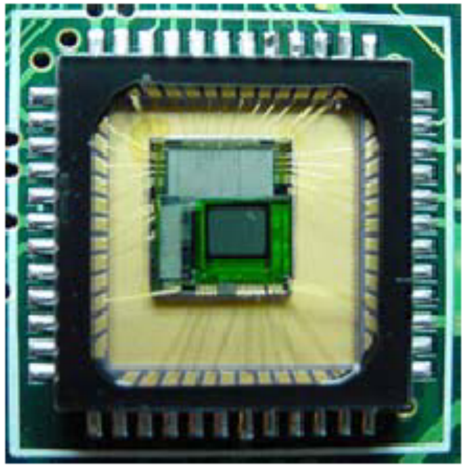
$$L = \rho \mathbf{I}^{\top} \mathbf{n}$$

where $\mathbf{I}$ is the direction and amount of incident light, $\mathbf{n}$ is the normal to the Lambertian surface. ρ is a positive constant called *surface's albedo*, which characterizes the surface's material.

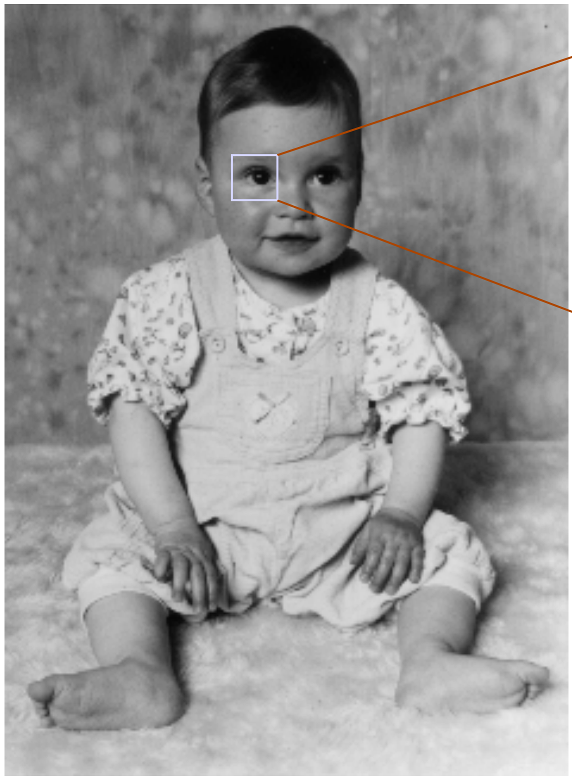
Cameras

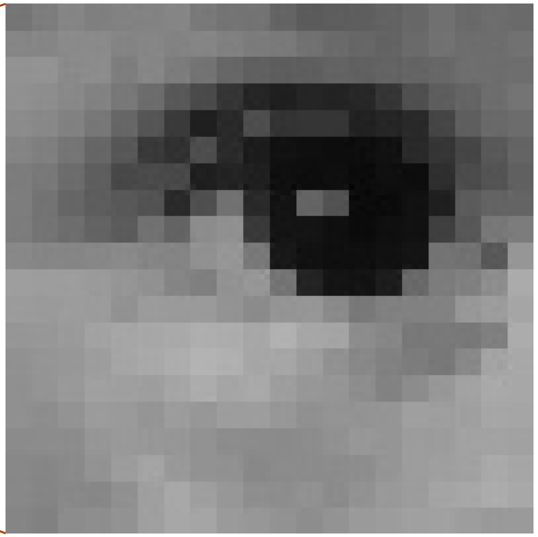
- Basic process:
  - photons hit a detector
  - the detector becomes charged
  - the charge is read out as brightness
- Sensor types:
  - CCD (charge-coupled device)
    - most common
    - high sensitivity
    - high power
    - cannot be individually addressed
    - blooming
  - CMOS
    - simple to fabricate (cheap)
    - lower sensitivity, lower power
    - can be individually addressed





Digital images





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Slides by D.A. Forsyth